AEROSPACE INDUSTRIES ASSOCIATION
western office
7660 Beverly Boulevard
Los Angeles 36, California

ATC Report No. ARTC-12

BASIC PROPERTIES FOR COMPARATIVE EVALUATION OF STRUCTURAL METALLIC MATERIALS

Revised
July 1, 1960

ATC Report No. ARTC-12

BASIC PROPERTIES FOR COMPARATIVE EVALUATION OF STRUCTURAL METALLIC MATERIALS

Revised
July 1, 1960

Prepared by the Aerospace Research and Testing Committee

Aerospace Industries Association of America, Inc.

P R E F A C E

The attached list of properties for evaluation of metallic materials has been compiled and approved by the W-88 Panel of the AIA/Aerospace Research and Testing Committee. An extensive revision to the presentation and content of the list was made as Project 6-59 and approved by the membership of ARTC. The list was prepared upon the request of numerous producers and testing agencies to attempt to clarify the aircraft industry's requirements for properties data.

The list of properties presented is extensive yet essential. It reflects the broad scope of environment (from liquefied gases to meteoric temperature of ballistic missiles) that will be encountered by the numerous types of vehicles that are being designed and considered for manufacture. After evaluation of a material and upon its selection for application to a specific aircraft or missile design, it will be necessary for the producer and user to obtain additional specific data.

When data are furnished in accordance with the tabulated requirements, it will be possible for all airframe manufacturers to properly evaluate an alloy. Potential markets will be uncovered by providing information which will be applicable to all manufacturers and test programs will actually be reduced in scope, cost and time.

Additional copies of this report may be obtained from

Technical Service
Aerospace Industries Association
7660 Beverly Boulevard
Los Angeles 36, California

BASIC PROPERTIES FOR COMPARATIVE EVALUATION OF STRUCTURAL METALLIC MATERIALS

SCOPE

1. The conditions of environment that are covered by all of the numerous aircraft and missile systems are very broad and varied. The following list attempts to obtain a minimum though adequate amount of data on a new alloy to determine whether a material is suitable for consideration in a specific design area. Such a list of properties is necessary because each new weapon system or missile will be designed to different exposure times, temperatures, deflection or creep limits, heating rates and loading rates and it will be impossible to obtain all potentially pertinent data on new alloys.

   Priority 1: The properties and technical information required by a user for an initial comparative evaluation of a new composition in order to identify a material for further consideration.

   Priority 2: Those additional properties required for a complete comparative evaluation. These data plus properties secured from Priority 1 list shall be sufficient to select a composition for a given airframe application.

   Priority 3: Those further properties required for structural design purposes. (These data would not normally become available until such time as sufficient interest is shown as a result of evaluation of Priority 1 and 2 data).

Note: Data developed from Priorities 1, 2 and 3 shall be considered adequate for design purposes only when tests are conducted (a) in accordance with recognized standards or mutually acceptable test methods, and (b) on a sufficient number of lots to insure reproducibility of results.

2. The list of data will permit evaluation for airframes and missiles structures but does not fully reflect the requirements of engines (chemical or nuclear); rocket motors; non-structural applications; research or laboratory investigation.

3. The usefulness of the list will be dependent upon eventually attaining standardized test procedures and test conditions for each property listed. When material properties are given, all factors pertaining to standardized procedures, optional test or specimen conditions, sheet or bar size, number of tests, heat treat condition and other technical details, should also be furnished.

4. The list has been divided into nine (9) general temperature classifications. A tenth class has been provided for those materials which the producer feels may be particularly useful in cryogenic applications. Materials tested in any of the other nine (9) conditions may also show promise for cryogenic use, and as such would also be tested in category A.

5. Where material properties can be altered considerably by heat treatment or cold working, the range of all affected properties should be indicated.

6. Testing should be carried out to the highest temperature practical. Many expendable missiles can be designed to very low stress levels using materials close to their melting point. It would, therefore, be to the advantage of the producers to carry their test programs out and obtain as much data on the properties under the extreme testing conditions as possible.

7. As <u>general requirements</u>, the material producer should provide as a Priority One item, the following information:

   A. <u>Availability</u>

      1. Ability of the material to be available in many forms (sheet and plate; extrusions; bars; tubular shapes; forgings; castings; wire and rod).

2. The presence of strategically critical alloying elements in the composition. (Nickel, cobalt, columbium, etc.)

3. The state of the art as related to the production of materials into desired shapes. (Research development; pilot development; production development; commercial production).

4. Commercial availability considerations. (Cost; single or multiple source availability; proprietary interest, patents, copyrights, trade secrets, etc.)

B. Processing Data

1. Producer should indicate range of properties that may be achieved by heat treatment, cold work, special processing techniques, transformation temperature, annealing temperature, recrystallization temperature, etc.

C. Fabricability

1. The amenability of the material to the several shaping processes. (This includes uniform elongation tests and minimum bend radius tests conducted at room temperature. Hot forming recommendations are desired).

2. The compatability of materials with joining processes and methods available. (Weldability)

(CHART I ARTC-12)

BASIC REQUIRED PROPERTIES FOR COMPARATIVE EVALUATION OF STRUC

MATERIALS CLASSED FOR STRUCTURAL USE AS FOLLOWS:

A CRYOGENIC APPLICATION POSSIBILITIES B USE TO 400°F C USE TO 600°F D USE

SECTION	ITEM	PROPERTIES	PRIORITY	EXPOSURE TIME	PROPERTIES REQUIRED FOR EACH MATERIAL CLAS (ALL TESTS LONGITUDINAL UNLESS OTHERWISE INDICATED - CL					
					-320	-423	-80	RT(1)	200	300
MECHANICAL PROPERTIES										
I		TENSION								
	A	Stress-Strain Curve (3)								
		1. To at least 0.3% Offset	1	1/2 hr	A	A	B-E	A-E(4)	B-C	B
			1	15 sec						
			2	500 hrs						B
		2. Complete Curve	3	1/2 hr	A	A	B-E	A-E(4)	B-C	B
	B	Tensile Properties								
		1. Tensile Ultimate	1	1/2 hr			DETERMINE FROM THE TEST SPECIM			
			1	15 sec						
			2	500 hrs						
		2. Tensile Yield (0.2% Offset)	1	1/2 hr			DETERMINE FROM THE STRESS-STR			
			1	15 sec						
			2	500 hrs						
		3. Elongation (5)	1	1/2 hr			DETERMINE FROM THE TEST SPECIM			
			1	15 sec						
			2	500 hrs						
		4. Reduction in Area (6)	1	1/2 hr			DETERMINE FROM THE TEST SPECIM			
			1	15 sec						
			2	500 hrs						
	C	Modulus of Elasticity								
		1. Tensile Modulus	1	1/2 hr			DETERMINE FROM THE STRESS-STR			
		2. Dynamic Modulus	2					B-E		
	D	Poisson's Ratio	1					B-E		
II		COMPRESSION								
	A	Stress-Strain Curve (3) to at least 0.3% Offset	2	1/2 hr	A	A	A	A-E(4)		B
			2	15 sec						
	B	Compressive Yield (0.2% Offset)	1	1/2 hr			DETERMINE FROM THE STRESS-STR			
			2	15 sec						
	C	Compressive Modulus	1	1/2 hr			DETERMINE FROM THE STRESS-STR			
III		TENSILE NOTCH SENSITIVITY (7)	1	1/2 hr	A	A	B-E	A-E(4)		
IV		SHEAR ULTIMATE STRENGTH	2	1/2 hr	A	A		A-E		B
V		MODULUS OF RIGIDITY	3					B-E		
VI		BEARING STRENGTH								
	A	Ultimate (e/D 1.5 and 2.0)	3	1/2 hr	A	A		A-E		
	B	Yield (2% Strain) (e/D 1.5 and 2.0)	3	1/2 hr			DETERMINE FROM A PLOT OF DEFLE			
VII		FATIGUE STRENGTH (Axial Tension-Tension) (8)								
	A	Smooth	3					B-E		
	B	Notched (K_T=3.0)	2					B-E		
VIII		CREEP IN TENSION								
	A	Time-Deformation Curve (To 500 Hours Maximum) (9)	2							B
	B	Creep Strengths								
		1. 0.2% Plastic Deformation (10) to 1000 Hours Maximum	3							B
		2. 1.0% Total Elongation (11) to 1000 Hours Maximum	3							B
		3 1.0% Total Elongation (11) to 5 Min. Maximum	3							B
IX		THERMAL STABILITY (12)								
	A	Under Load	2					B-E		
	B	Under No Load	1					B-E		
X		IMPACT STRENGTH (V-notch Charpy) (6)	2	1/2 hr	A	A	B-E	A-E		
PHYSICAL PROPERTIES										
XI		DENSITY	1					B-E		

(CHART I ARTC-12)

PLASTEC REF. 1176

COMPARATIVE EVALUATION OF STRUCTURAL METALLIC MATERIALS

RIALS CLASSED FOR STRUCTURAL USE AS FOLLOWS:

B USE TO 400°F C USE TO 600°F D USE TO 800°F E USE TO 1000°F

EXPOSURE TIME	PROPERTIES REQUIRED FOR EACH MATERIAL CLASS AT TEMPERATURES (°F) INDICATED (ALL TESTS LONGITUDINAL UNLESS OTHERWISE INDICATED - CLASS INDICATIONS ARE INCLUSIVE - SEE NOTE 2)											
	-320	-423	-80	RT(1)	200	300	400	500	600	800	1000	1200	1400
½ hr	A	A	B-E	A-E(4)	B-C	B	B-D	C	C-E	D-E	E		
15 sec								B	B-C	C-D	C-E	D-E	E
500 hrs						B	B	C	C-D	D-E	E		
½ hr	A	A	B-E	A-E(4)	B-C	B	B-D	C	C-E	D-E	E		
½ hr 15 sec 500 hrs			DETERMINE FROM THE TEST SPECIMENS USED IN SECTION IA										
½ hr 15 sec 500 hrs			DETERMINE FROM THE STRESS-STRAIN CURVES OF SECTION IA										
½ hr 15 sec 500 hrs			DETERMINE FROM THE TEST SPECIMENS USED IN SECTION IA										
½ hr 15 sec 500 hrs			DETERMINE FROM THE TEST SPECIMENS USED IN SECTION IA										
½ hr			DETERMINE FROM THE STRESS-STRAIN CURVES OF SECTION IA										
				B-E			B		C	D	E		
				B-E									
½ hr	A	A	A	A-E(4)		B	B-C		C-D	D-E	E		
15 sec							B		C	D	E		
½ hr 15 sec			DETERMINE FROM THE STRESS-STRAIN DIAGRAMS OF SECTION IIA										
½ hr			DETERMINE FROM THE STRESS-STRAIN DIAGRAMS OF SECTION IIA										
½ hr	A	A	B-E	A-E(4)									
½ hr	A	A		A-E		B	B-C		C-D	D-E	E		
				B-E									
½ hr	A	A		A-E			B		C	D	E		
½ hr			DETERMINE FROM A PLOT OF DEFLECTION DATA FROM TESTS OF SECTION VI A										
				B-E									
				B-E									
						B	B	C	C-D	D-E	E		
						B	B	C	C-D	D-E	E		
						B	B	C	C-D	D-E	E		
						B	B	C	C-D	D-E	E		
				B-E									
				B-E									
½ hr	A	A	B-E	A-E									
				B-E									

III	TENSILE NOTCH SENSITIVITY (7)	1	½ hr	A	A	B-E	A-E(4)		
IV	SHEAR ULTIMATE STRENGTH	2	½ hr	A	A		A-E		B
V	MODULUS OF RIGIDITY	3					B-E		
VI	BEARING STRENGTH								
	A Ultimate (e/D 1.5 and 2.0)	3	½ hr	A	A		A-E		
	B Yield (2% Strain) (e/D 1.5 and 2.0)	3	½ hr			DETERMINE FROM A PLOT OF DEFL			
VII	FATIGUE STRENGTH (Axial Tension-Tension) (8)								
	A Smooth	3					B-E		
	B Notched (K_T=3.0)	2					B-E		
VIII	CREEP IN TENSION								
	A Time-Deformation Curve (To 500 Hours Maximum) (9)	2							B
	B Creep Strengths								
	1. 0.2% Plastic Deformation (10) to 1000 Hours Maximum	3							B
	2. 1.0% Total Elongation (11) to 1000 Hours Maximum	3							B
	3. 1.0% Total Elongation (11) to 5 Min. Maximum	3							B
IX	THERMAL STABILITY (12)								
	A Under Load	2					B-E		
	B Under No Load	1					B-E		
X	IMPACT STRENGTH (V-notch Charpy) (6)	2	½ hr	A	A	B-E	A-E		
	PHYSICAL PROPERTIES								
XI	DENSITY	1					B-E		
XII	COEFFICIENT OF THERMAL EXPANSION (Mean) (13)	1		A	A	A-E(13)		B-E(14)	B (14)
XIII	CONDUCTIVITY								
	A Thermal	1					B-E		
	B Electrical	3					B-E		
XIV	SPECIFIC HEAT (15)	1					B-E	B	B
XV	EMISSIVITY	3							B
XVI	MAGNETIC PERMEABILITY (at 200 Oersteds)	3					B-E		
XVII	OXIDATION RESISTANCE (16)	1							C
XVIII	CORROSION RESISTANCE (17)	1					A-E		

NOTES:

(1) Exposure time reference does not apply.

(2) Data required to at least 100° F beyond the point where a marked decline in useful strength occurs (in order to establish the shape of the curve for the exposure time of interest.)

(3) Strain magnification shall be adjusted so that the slope of the elastic portion of the stress-strain curve shall be between 45° and 75° from the abcissa. This is to permit more accurate determination of tangent modulus between the proportional limit and the 0.2% offset yield strength.

(4) Test desired in both longitudinal and transverse directions. Where the material is intended for bar or forging applications, short transverse testing will also be accomplished.

(5) Total elongation in gage length measured on broken specimens for all tests. In addition, uniform elongation to be measured at R.T.

(6) To be determined only on bar, plate and forging products.

(7) Ratio of notched (K_T=3.0) to unnotched (Section IA) tensile strength of bar or plate products. This test is to be run at sufficient temperatures to determine the brittle-to-ductile transition if one exists above R.T.

(8) S-n curve to 10^7 cycles (5 points)
Smooth specimen, stress ratio, R=0.1
Notched specimen, stress ratio, R=0.1, K_T=3.0

(9) At a stress 1/3 ul
temperature. Cu

(10) Total permanen
loading plus cre

(11) Total elongation
excluding therm

(12) Thermal (under
on deformed spe
Report permanen
Thermal (under
at service temp

(13) Mean value bet

(14) Mean value bet

(15) Priority 1 for F

(16) Report loss in r
loss in weight,

(17) To conform to t

15 sec							B		C	D	E	
½ hr 15 sec			DETERMINE FROM THE STRESS-STRAIN DIAGRAMS OF SECTION IIA									
½ hr			DETERMINE FROM THE STRESS-STRAIN DIAGRAMS OF SECTION IIA									
½ hr	A	A	B-E	A-E(4)								
½ hr	A	A		A-E B-E		B	B-C		C-D	D-E	E	
½ hr	A	A		A-E			B		C	D	E	
½ hr			DETERMINE FROM A PLOT OF DEFLECTION DATA FROM TESTS OF SECTION VI A									
				B-E B-E								
						B	B	C	C-D	D-E	E	
						B	B	C	C-D	D-E	E	
						B	B	C	C-D	D-E	E	
						B	B	C	C-D	D-E	E	
				B-E B-E								
½ hr	A	A	B-E	A-E								
				B-E								
	A	A	A-E(13)		B-E(14)	B (14)	B-F(14)		C-E(14)	D-E(14)	E (14)	
				B-E B-E								
				B-E	B	B	B-D		C-E	D-E	E	
						B	B-C		C-D	D-E	E	
				B-E								
						C		C-E		D-E	E	
				A-E								

arked decline in
curve for the

he elastic portion of
the abcissa. This
between the

. Where the
transverse

nens for all tests. In

sile strength of bar
peratures to
ove R.T.

(9) At a stress ⅓ ultimate or ½ yield strength, whichever is lower at test temperature. Curve to delineate primary creep as well as secondary creep.

(10) Total permanent set during time span to include plastic deformation upon loading plus creep. (Time - deformation curves to be available upon request).

(11) Total elongation is total extension in test (elastic plus plastic strain plus creep), excluding thermal expansion. (Time-deformation curves to be available upon request).

(12) Thermal (under load) - Determine tensile ultimate, yield strength and elongation on deformed specimens from creep tests which were discontinued before fracture. Report permanent deformation before testing.

Thermal (under no load) - Tested at room temperature after 500 hours exposure at service temperature.

(13) Mean value between the temperature indicated and 78° F.

(14) Mean value between 78°F and temperature indicated.

(15) Priority 1 for R.T. tests, Priority 2 for elevated temperature tests.

(16) Report loss in metal thickness, adhered oxide thickness (metallographically) and loss in weight, versus time at temperature.

(17) To conform to the latest revision of Federal Test Method 151.

BASIC REQUIRED PROPERTIES FOR COMPARATIVE EVALUATION OF STF

MATERIALS CLASSED FOR STRUCTURAL USE AS FOLLOWS

F USE TO 1200°F G USE TO 1600°F H USE TO 2000°F I USE TO 2

SECTION	ITEM	PROPERTIES	PRIORITY	EXPOSURE TIME	PROPERTIES REQUIRED AT INDICATED TE SPECIFIED. CLASS INDICATIONS ARE INCLUSIVE-SEE			
					R.T.(1)	800	1000	1200
MECHANICAL PROPERTIES								
I		TENSION						
	A	Stress-Strain Curve (3)						
		1. To at least 0.3% Offset	1	1/2 HR	F-J(4)	F	F	F-J
			1	15 SEC				F
			2				F(500 Hr)	F(500 Hr)
		2. Complete Curve	3	1/2 HR	F-J(4)			F
	B	Tensile Properties						
		1. Tensile Ultimate	1	1/2 HR				
			1	15 SEC		DETERMINE FROM THE TEST		
			2					
		2. Tensile Yield (0.2%)	1	1/2 HR				
			1	15 SEC		DETERMINE FROM THE STRE		
			2					
		3. Elongation (5)	1	1/2 HR				
			1	15 SEC				
			2			DETERMINE FROM THE TESTS		
		4. Reduction In Area (6)	1	1/2 HR				
			1	15 SEC		DETERMINE FROM THE TESTS		
			1					
	C	Modulus of elasticity						
		1. Tensile Modulus	1	1/2 HR		DETERMINE FROM THE STRE		
		2. Dynamic Modulus	2	1/2 HR	F-J			
	D	Poissons Ratio	1		F-J			
II		COMPRESSION						
	A	Stress Strain Curve (3)	2	1/2 HR	F-J(4)		F	F-J
		To At Least 0.3% Offset	2	15 SEC				F
	B	Compressive Yield (0.2% Offset)	1	1/2 HR				
			2	15 SEC		DETERMINE FROM THE STRE		
	C	Compressive Modulus	1	1/2 HR		DETERMINE FROM THE STRE		
III		TENSILE NOTCH SENSITIVITY (7)	1	1/2 HR	F-J(4)	H-J	H-J	
IV		SHEAR ULTIMATE STRENGTH	2	1/2 HR	F-J	F		F-J
V		MODULUS OF RIGIDITY	3		F-J			
VI		BEARING STRENGTH						
	A	Ultimate ($^{e}/_{D}$ Of 1.5 And 2.0)	3	1/2 HR	F-J			F
	B	Yield (2% Strain) ($^{e}/_{D}$ Of 1.5 And 2.0)	3	1/2 HR	F-J	DETERMINE FROM A PLOT		
VII		FATIGUE STRENGTH (Axial Tension-Tension) (8)						
	A	Smooth Specimen	3		F-J			
	B	Notched Specimen ($K_T = 3.0$)	2		F-J		H-J	
VIII		CREEP IN TENSION						
	A	Time Deformation Curve (9)	2				F	F
	B	Creep Strengths						
		1. 0.2% Plastic Deformation (10)	3				F	F
		2. 1.0% Total Deformation (11)	3				F	F
		3. 1.0% Total Deformation To 5 Min. Max. (11)	3					F
IX		THERMAL STABILITY (12)						
	A	Under Load	2		F-J			
	B	Under No Load	1		F-J			
X		IMPACT STRENGTH (V-Notch Charpy) (6)	2		F-J		H-J	
PHYSICAL PROPERTIES								
XI		DENSITY	1		F-J			
XII		COEFFICIENT OF THERMAL EXPANSION (mean) (13)	1			F	F-J	F-G
X		CONDUCTIVITY						
	A	THERMAL	1		F-J			F
	B	ELECTRICAL	3		F-J			
XIV		SPECIFIC HEAT (15)	1		F-J	F-J	F	F-J
XV		EMISSIVITY (16)	3					F-J

(CHART II ARTC-12)

PLASTEC REF. 1176

R COMPARATIVE EVALUATION OF STRUCTURAL METALLIC MATERIALS

MATERIALS CLASSED FOR STRUCTURAL USE AS FOLLOWS:

G USE TO 1600°F H USE TO 2000°F I USE TO 2500°F J USE TO 3000°F

IORITY	EXPOSURE TIME	PROPERTIES REQUIRED AT INDICATED TEMPERATURES (°F) (ALL TESTS IN LONGITUDINAL DIRECTION UNLESS SPECIFIED. CLASS INDICATIONS ARE INCLUSIVE - SEE NOTE #2)									
		R.T.(1)	800	1000	1200	1400	1600	1800(13)	2000(13)	2500(13)	3000(13)
1	1/2 HR	F-J(4)	F	F	F-J	G	G-H	H-I	H-J	I-J	J
1	15 SEC				F	F	F-G	G	G-H	I	J
2				F(500 Hr)	F(500 Hr)	G(500 Hr)	G(500 Hr)	H(100 Hr)	H-I(100 Hr)	I (5 Hr)	J(5 Hr.)
3	1/2 HR	F-J(4)			F		G		H	I	J
1	1/2 HR		DETERMINE FROM THE TESTS OF SECTION IA								
1	15 SEC										
2											
1	1/2 HR		DETERMINE FROM THE STRESS-STRAIN DIAGRAMS OF SECTION IA								
1	15 SEC										
2											
1	1/2 HR		DETERMINE FROM THE TESTS OF SECTION IA								
1	15 SEC										
2											
1	1/2 HR		DETERMINE FROM THE TESTS OF SECTION IA								
1	15 SEC										
1											
1	1/2 HR		DETERMINE FROM THE STRESS-STRAIN DIAGRAM OF SECTION IA								
2	1/2 HR	F-J									
1		F-J									
2	1/2 HR	F-J(4)		F	F-J	G	G	H	H-J	I	J
2	15 SEC				F	F	G	G	H	H-I	I-J
1	1/2 HR		DETERMINE FROM THE STRESS-STRAIN DIAGRAMS OF SECTION II A								
2	15 SEC										
1	1/2 HR		DETERMINE FROM THE STRESS-STRAIN DIAGRAM OF SECTION II A								
1	1/2 HR	F-J(4)	H-J	H-J							
2	1/2 HR	F-J	F		F-J		G-H		H-J	I	J
3		F-J									
3	1/2 HR	F-J			F		G		H	I	J
3	1/2 HR	F-J	DETERMINE FROM A PLOT OF DEFLECTION DATA FROM TESTS OF SECTION VI A								
3		F-J									
2		F-J		H-J							
2				F	F	G	G	H	H-I	I-J	J
3				F	F	G	G	H	H-I	I-J	J
3				F	F	G	G	H	H-I	I-J	J
3					F		G		H	I	J
2		F-J									
1		F-J									
2		F-J		H-J							
1		F-J									
1			F	F-J	F-G	G	G-J	H	H-J	I-J	J
1		F-J			F		G-J		H-J	I	J
3		F-J									
1		F-J	F-J	F	F-J		G-J		H-J	I-J	J
3					F-J		G		H-J	I	J

	A Smooth Specimen	3		F-J			
	B Notched Specimen ($K_T = 3.0$)	2		F-J		H-J	
VIII	CREEP IN TENSION						
	A Time Deformation Curve (9)	2				F	F
	B Creep Strengths						
	1. 0.2% Plastic Deformation (10)	3				F	F
	2. 1.0% Total Deformation (11)	3				F	F
	3. 1.0% Total Deformation To 5 Min. Max. (11)	3					F
IX	THERMAL STABILITY (12)						
	A Under Load	2		F-J			
	B Under No Load	1		F-J			
X	IMPACT STRENGTH (V-Notch Charpy) (6)	2		F-J		H-J	
	PHYSICAL PROPERTIES						
XI	DENSITY	1		F-J			
XII	COEFFICIENT OF THERMAL EXPANSION (mean)(13)	1			F	F-J	F-G
X	CONDUCTIVITY						
	A THERMAL	1		F-J			F
	B ELECTRICAL	3		F-J			
XIV	SPECIFIC HEAT (15)	1		F-J	F-J	F	F-J
XV	EMISSIVITY (16)	3					F-J
XVI	MAGNETIC PERMEABILITY (At 200 Oersteds)	3		F-J			
XVII	OXIDATION RESISTANCE (16)	1					F-J
XVIII	CORROSION RESISTANCE (17)	1		F-J			

NOTES:

(1) Exposure time reference does not apply.

(2) Data required to at least 100° F beyond the point where a marked decline in useful strength occurs (in order to establish the shape of the curve for the exposure time of interest.)

(3) Strain magnification shall be adjusted so that the slope of the elastic portion of the stress-strain curve shall be between 45° and 75° from the abcissa. This is to permit more accurate determination of tangent modulus between the proportional limit and the 0.2% offset yield strength.

(4) Test desired in both longitudinal and transverse directions. Where the material is intended for bar or forging applications, short transverse testing will also be accomplished.

(5) Total elongation in gage length measured on broken specimens for all tests. In addition, uniform elongation to be measured at R.T.

(6) To be determined only on bar, plate and forging products.

(7) Ratio of notched ($K_T = 3.0$) to unnotched (Section IA) tensile strength of bar or plate products. This test is to be run at sufficient temperatures to determine the brittle-to-ductile transition if one exists above R.T.

(8) S-n curve (5 points) to 10^7 cycles for class F, G and H materials and to 10^6 cycles for class I and J materials.
Smooth specimen, stress ratio, R = 0.1
Notched specimen, stress ratio, R = 0.1 , $K_T = 3.0$

(9) At a stress 1/3 ultimate or 1/2 yield strength, whichever is lower at test temperature. Curve to delineate primary creep as well as secondary creep.

(10) Total permanent set d
loading plus creep. (1

(11) Total elongation is tot
excluding thermal exp

(12) Thermal (under load) - [
deformed specimens fr
Report permanent defo

Thermal (under no load
1600° F for 500 hour
5 minutes, whichever i

(13) Test atmosphere and/c
testing techniques pecu
test temperatures (bet
necessary to fully des

(14) Mean value between 7

(15) Priority 1 for R.T. tes

(16) Report loss in metal t
loss in weight, versus t

(17) To conform to the lates

JULY 1, 1960

3	1/2HR	F-J			F		G		H	I	J
3	1/2HR	F-J	DETERMINE FROM A PLOT OF DEFLECTION DATA FROM TESTS OF SECTION VI A								
3		F-J									
2		F-J		H-J							
2				F	F	G	G	H	H-I	I-J	J
3				F	F	G	G	H	H-I	I-J	J
3				F	F	G	G	H	H-I	I-J	J
3					F		G		H	I	J
2		F-J									
1		F-J									
2		F-J		H-J							
1		F-J									
1			F	F-J	F-G	G	G-J	H	H-J	I-J	J
1		F-J			F		G-J		H-J	I	J
3		F-J									
1		F-J	F-J	F	F-J		G-J		H-J	I-J	J
3					F-J		G		H-J	I	J
3		F-J									
1					F-J		G-J		H-J	I-J	J
1		F-J									

ere a marked decline in
e of the curve for the

ope of the elastic portion of
° from the abcissa. This
modulus between the
h.

ections. Where the
short transverse

specimens for all tests. In

roducts.

IA) tensile strength of bar
nt temperatures to
xists above R.T.

H materials and to 10^6 cycles

ver is lower at test
ll as secondary creep.

(10) Total permanent set during time span to include plastic deformation upon loading plus creep. (Time - deformation curves to be available upon request).

(11) Total elongation is total extension in test (elastic plus plastic strain plus creep), excluding thermal expansion. (Time-deformation curves to be available upon request).

(12) Thermal (under load) - Determine tensile ultimate, yield strength and elongation on deformed specimens from creep tests which were discontinued before fracture. Report permanent deformation before testing.

Thermal (under no load) - Tested at room temperature after exposure to 1200 or 1600° F for 500 hours, or to 2000° F for 100 hours, or to 2500 or 3000° for 5 minutes, whichever is applicable.

(13) Test atmosphere and/or protective coating used shall be reported as shall any testing techniques peculiar to the temperatures or materials involved. Additional test temperatures (between or above those indicated) will be used as judged necessary to fully describe the materials capabilities.

(14) Mean value between 78°F and temperature indicated.

(15) Priority 1 for R.T. tests, Priority 2 for elevated temperature tests.

(16) Report loss in metal thickness, adhered oxide thickness (metallographically) and loss in weight, versus time at temperature.

(17) To conform to the latest revision of Federal Test Method 151.